Solid Oxide Fuel Cell Hybrids: Challenges & Benefits

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GE Hybrid Power Generation Systems

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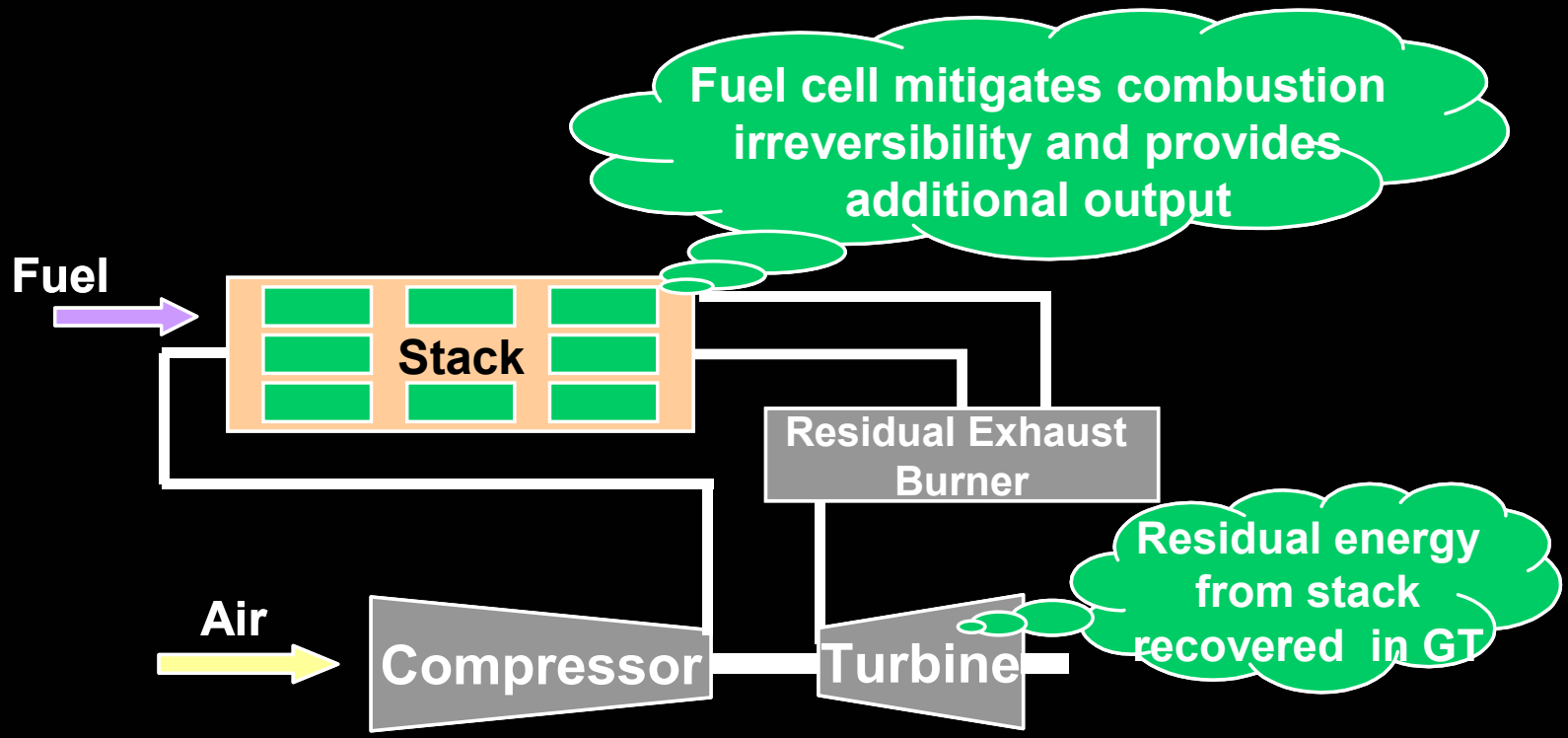
Agenda

- Issues
- Benefits
- Challenges
- Summary

Issues

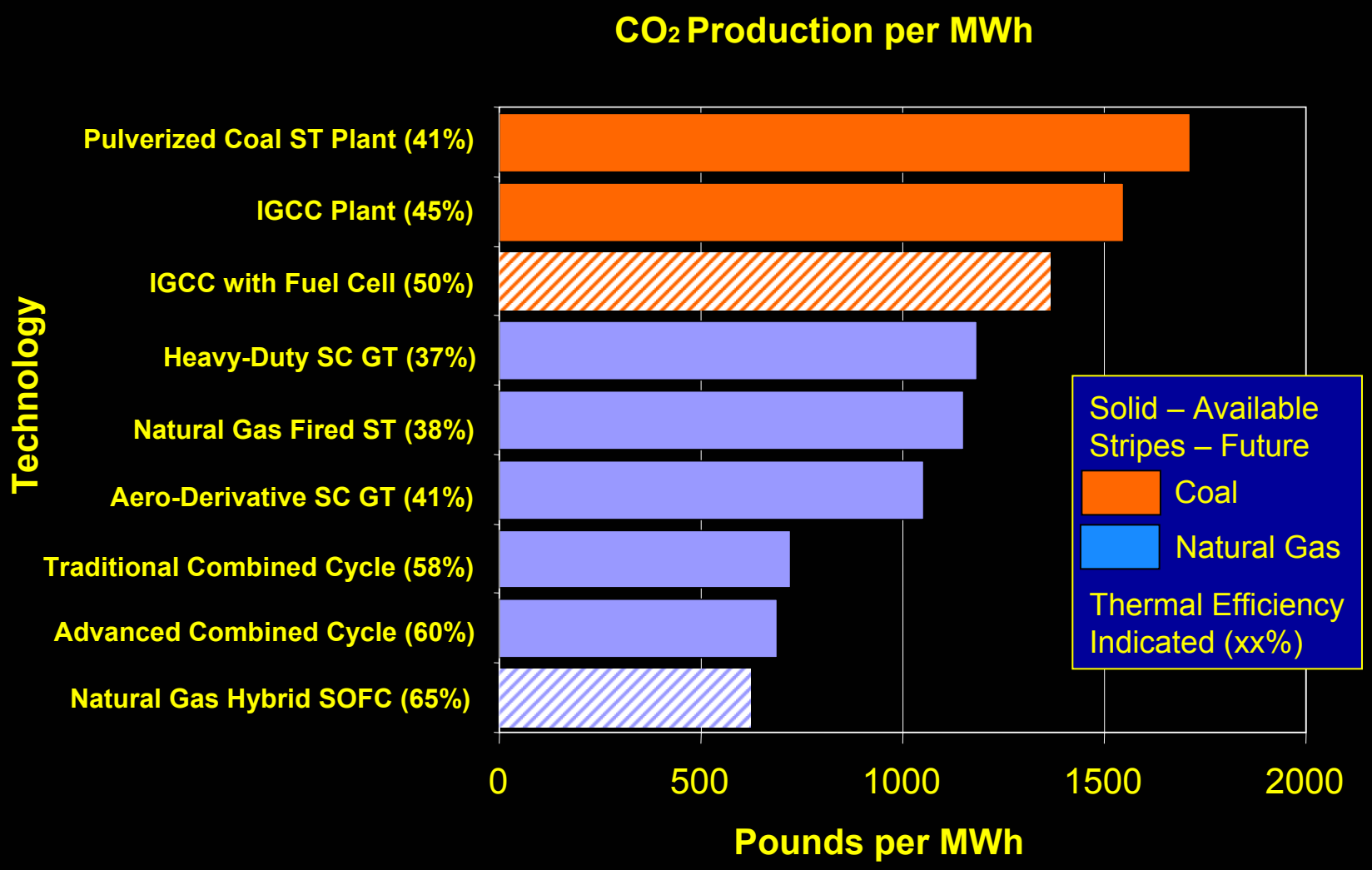
- Growing rate and changing patterns of power consumption
- Transmission and distribution concerns
- Desire for reduced emissions
- More efficient use of natural resources
- Energy independence
- Use of indigenous fuels

SOFC/GT Hybrid Concept



Attractive efficiency and emissions, but challenges remain

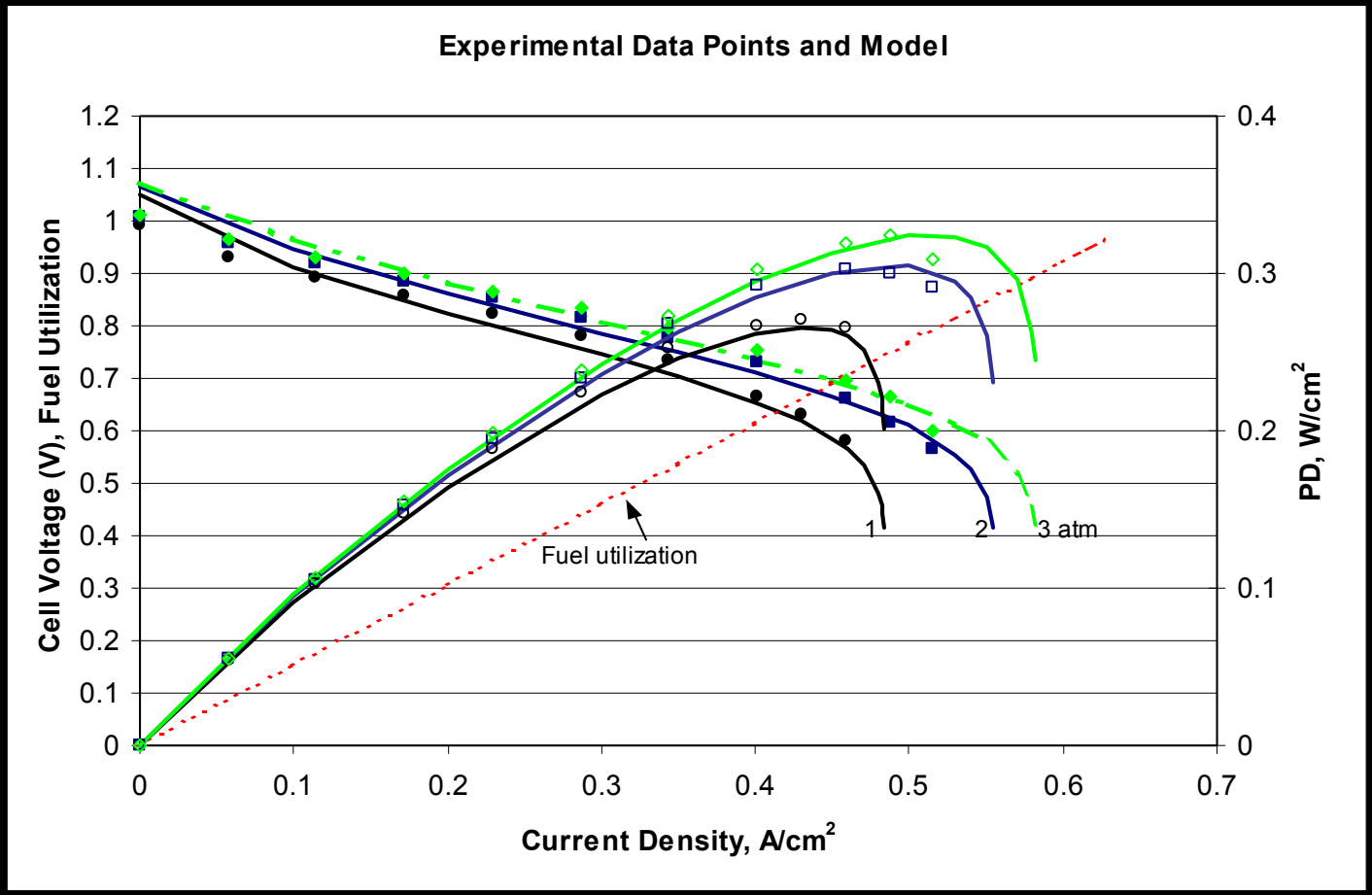
CO_2 Production: Today and Future



Technical Challenges

	SECA & Simple Cycle	SOFC/Hybrid
Low Cost Manufacturing	✓	✓
Cell Life	✓	✓
Cell & Stack Power Density	✓	✓
Stack and System Thermal Management	✓	✓
Power Conditioning	✓	✓
Controls	✓	✓
Fuel Processing	✓	✓
Scale-Up		✓
Pressurized Operation		✓
Hybrid Systems Design & Integration		✓

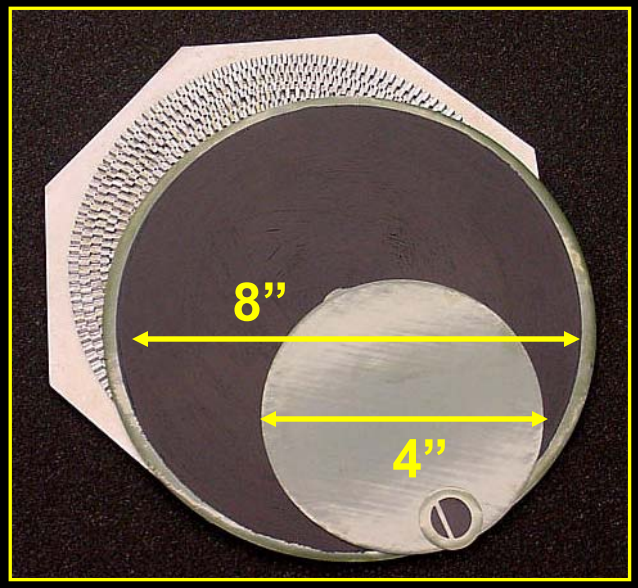
Pressurized Operation and Model



Improvements in power density needed for cost viability

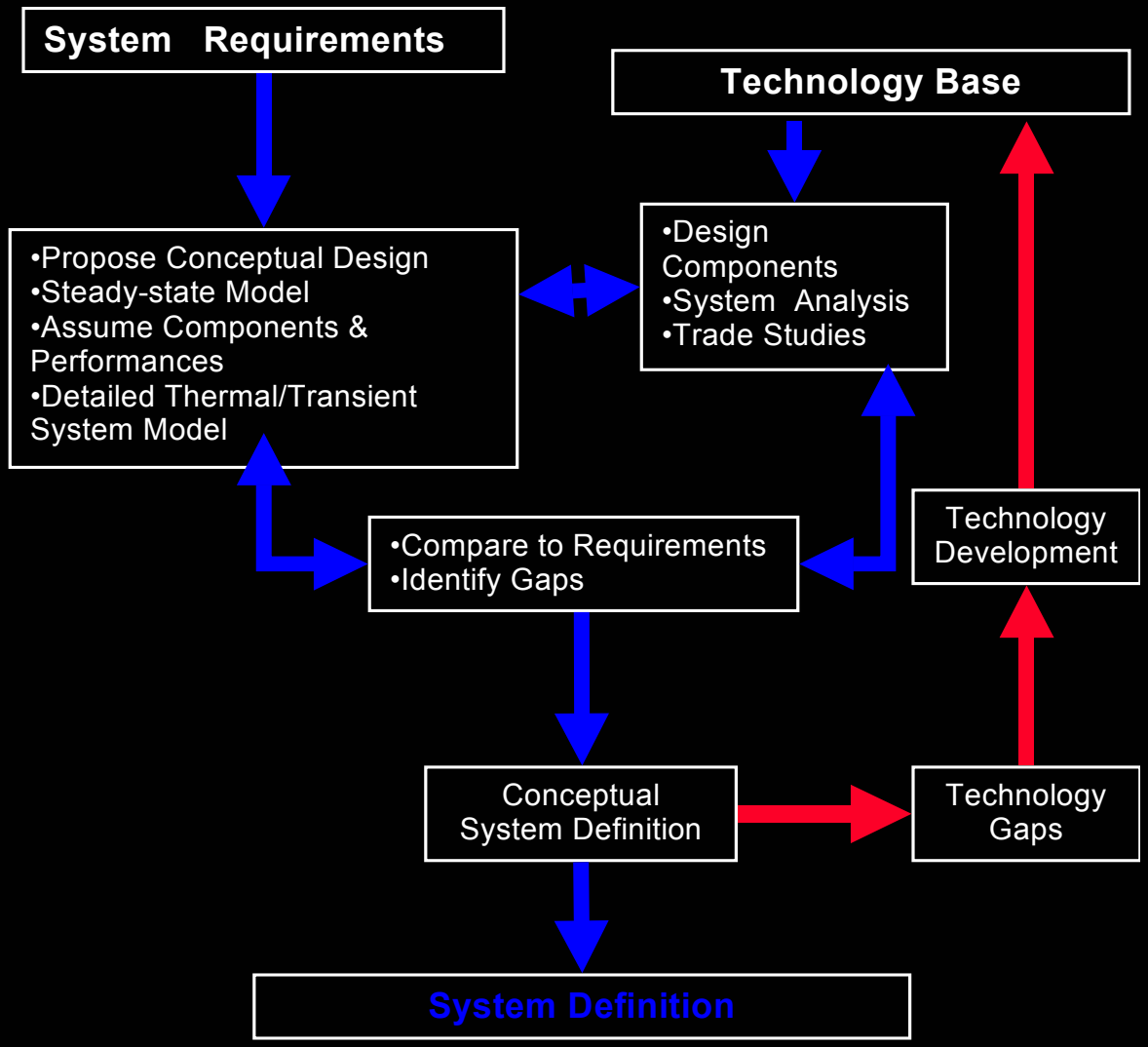
Scale Up

Cell Diameter	Number of Cells
4"	99000
8"	25000
12"	11000
18"	4900

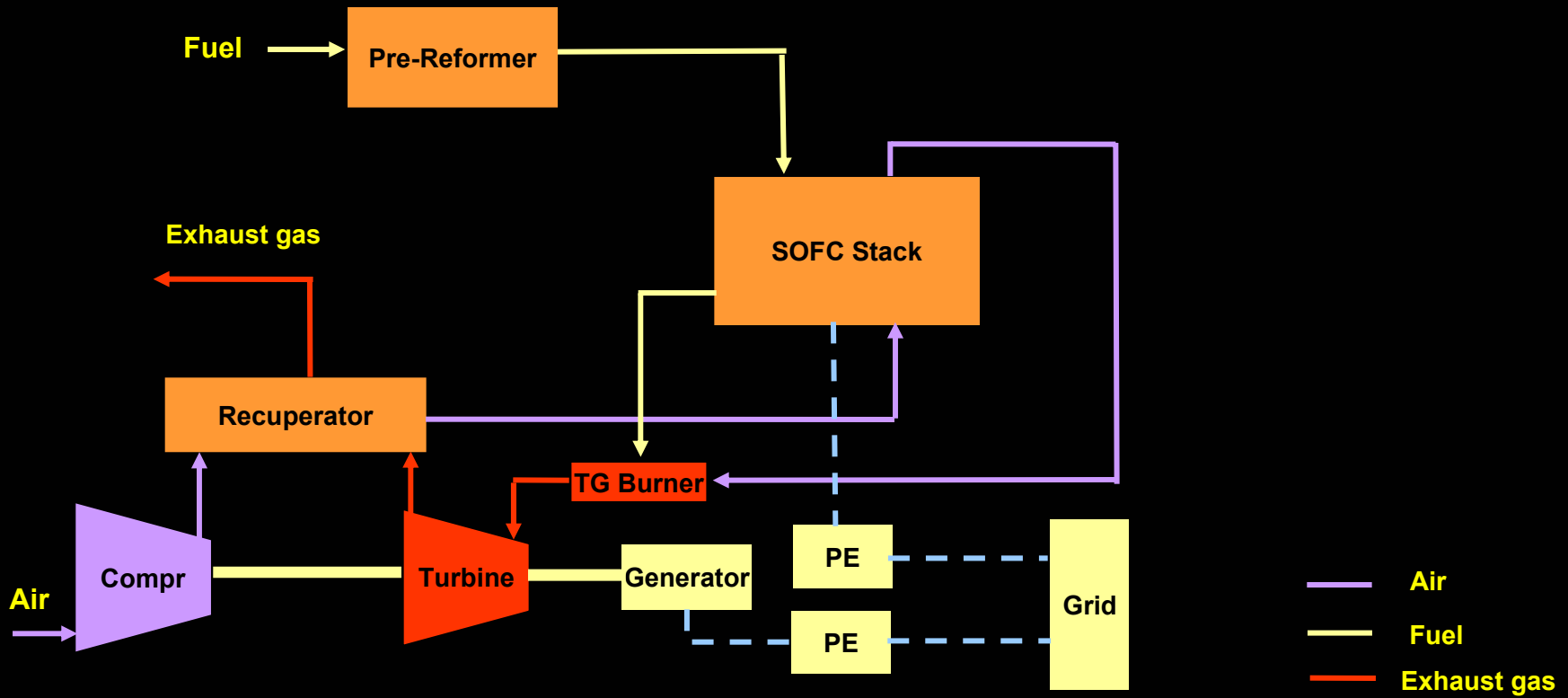


Large footprint needed for MW-class systems

Integrated Hybrid System Design



SOFC Hybrid Conceptual Design

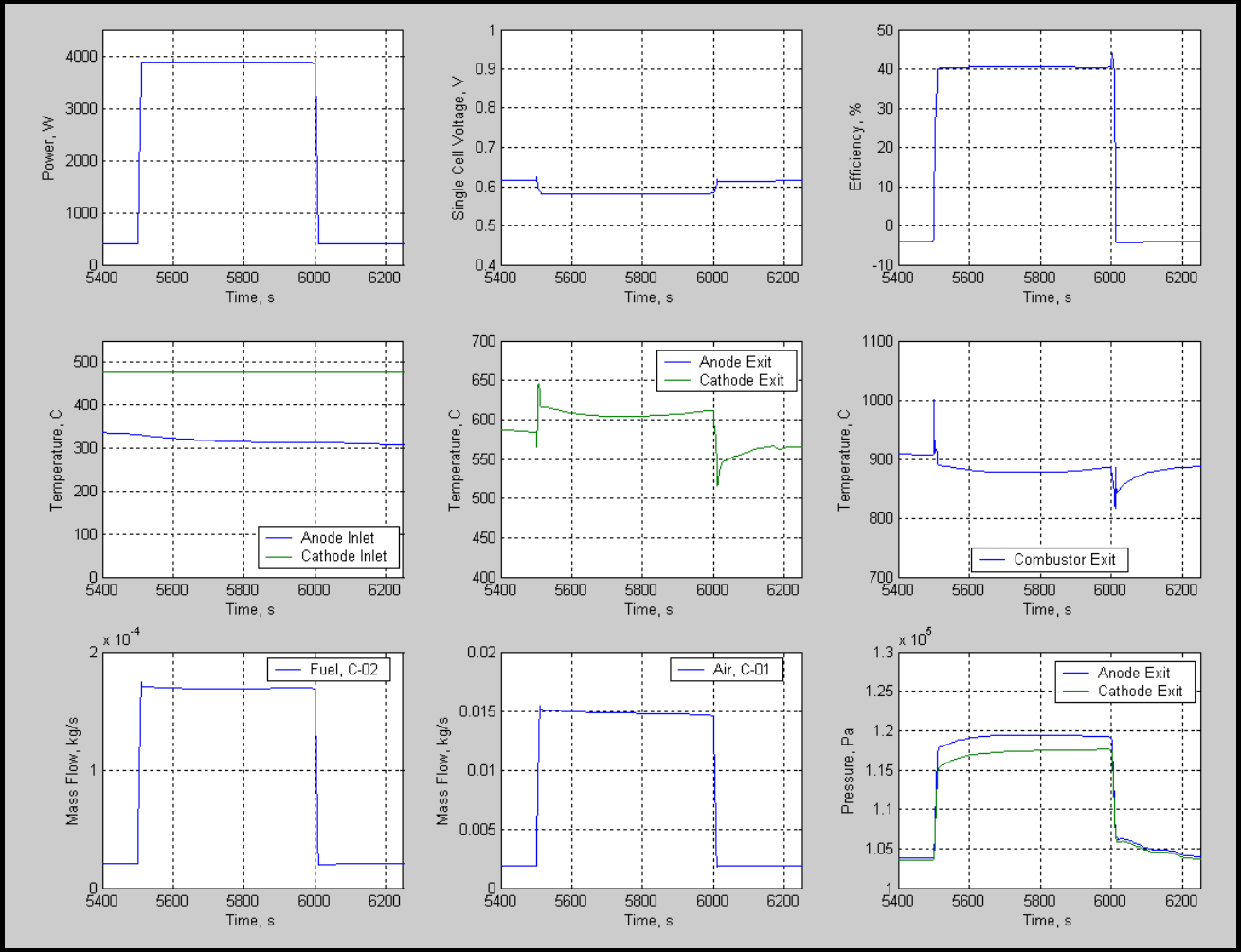


- Multi-fuel capable
- Efficiency entitlement 5- 15% above combustion technologies
- Low emissions

Many requirements to be met simultaneously

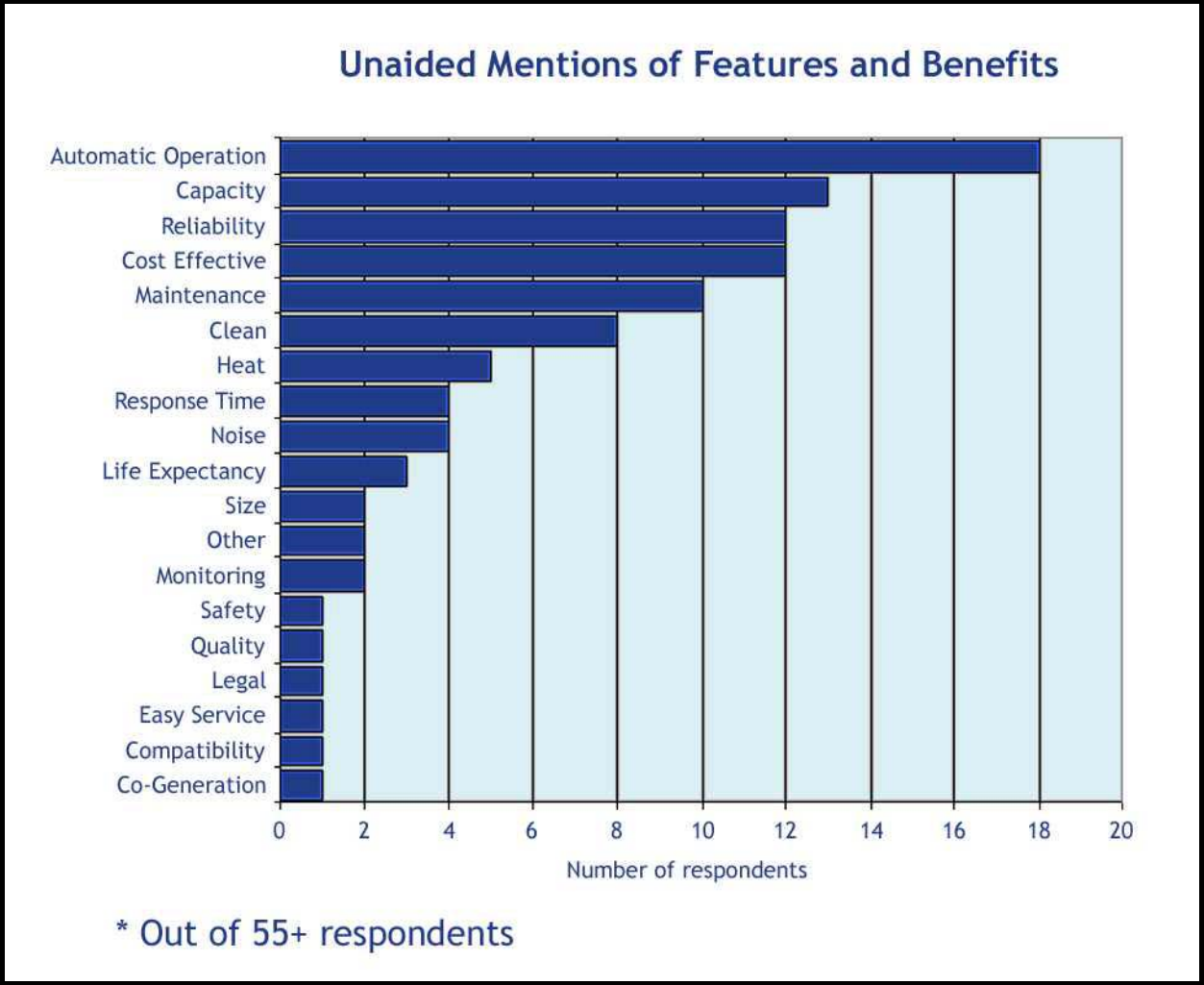
Controls

- Ramp increase in power from 0% to 75% load in 10 seconds
- SOFC temperature too low resulting in poor performance
- Further analysis is needed



Preliminary Results – Simple Cycle System

Customers Want….



Traditional factors at top of mind

Why will customers buy SOFC and SOFC/hybrid?

Competitive COE difficult with small, simple cycle SOFC

Rely on complementary value propositions

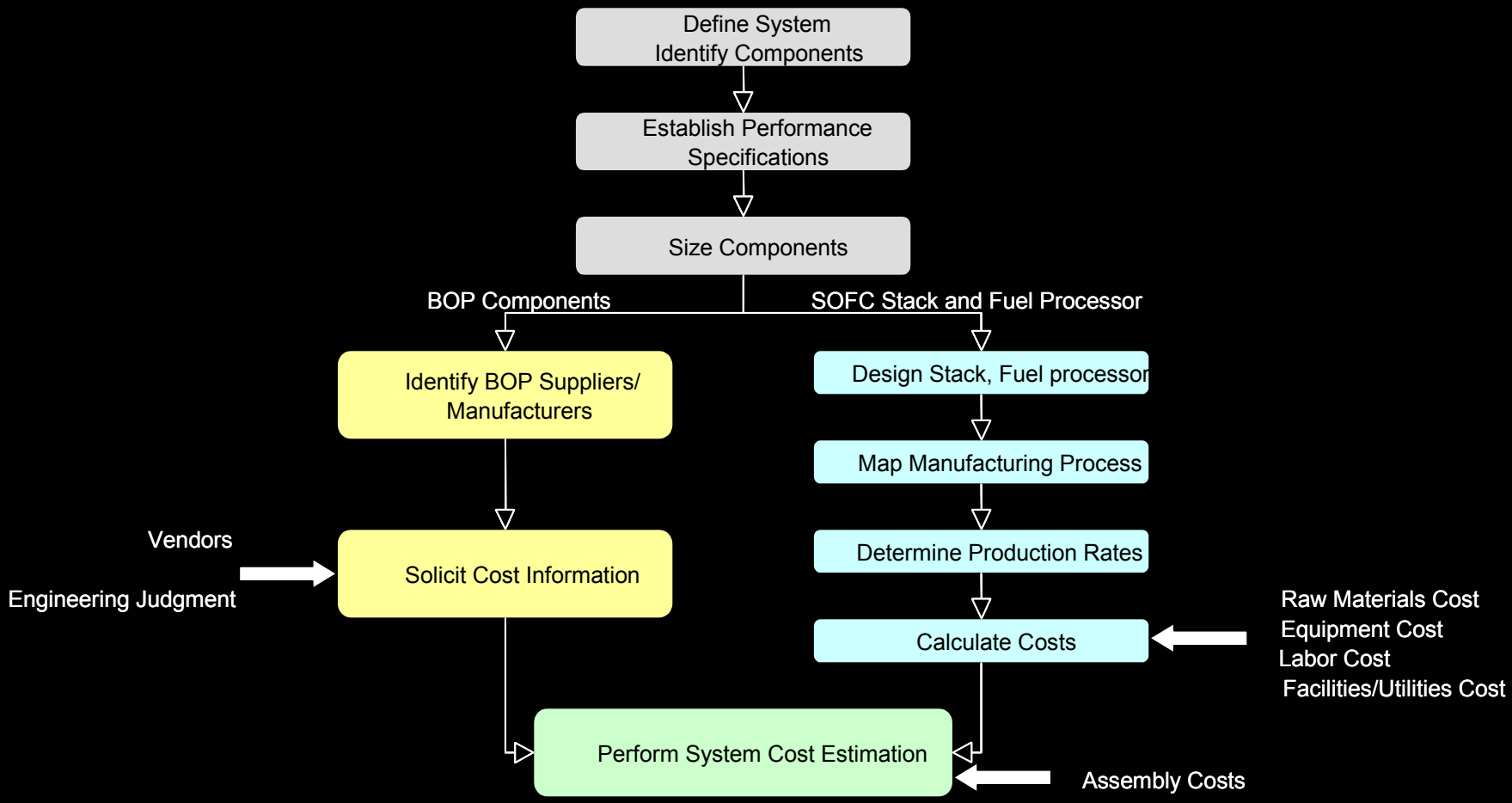
- Reliable power
- High quality power
- Environmental benefits
- Cogeneration opportunities
- Portable power

Large SOFC hybrids can compete on COE

- Competitive in some applications at $600 - $800/kW
- Potentially disruptive at lower price
- Potential for use with gasified coal, hydrogen, other fuels

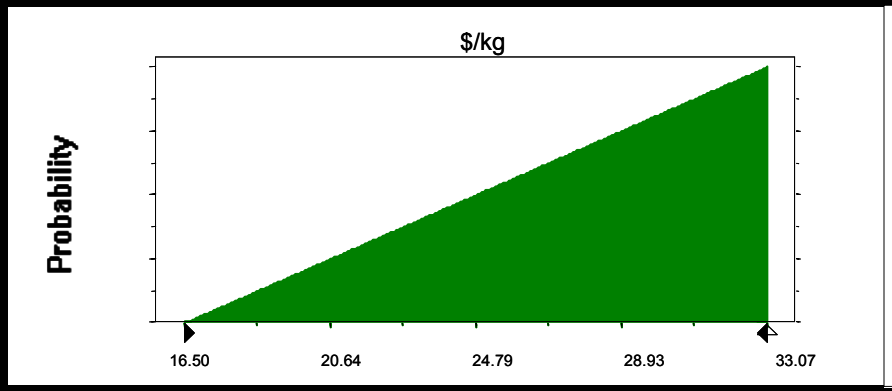
Early strategy must focus on customers with compelling needs

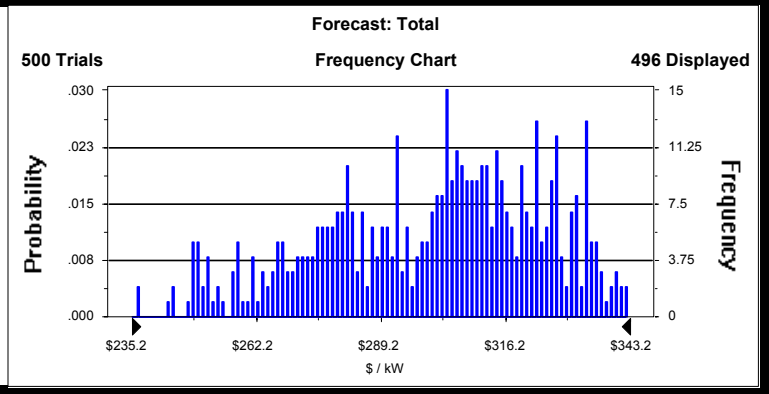
Cost Estimation

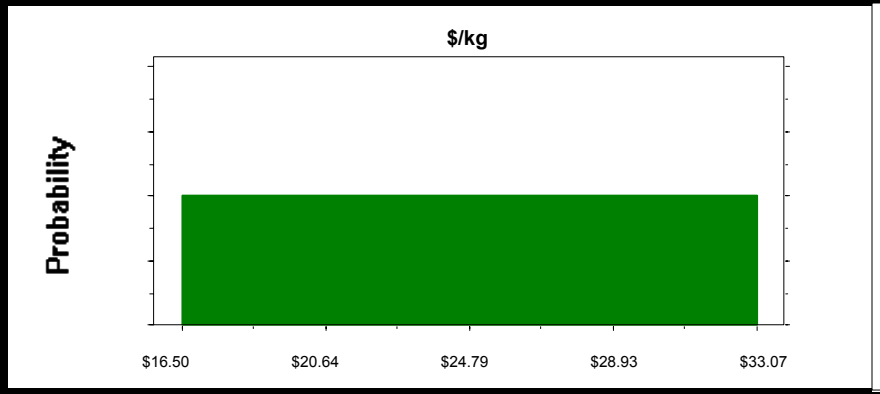


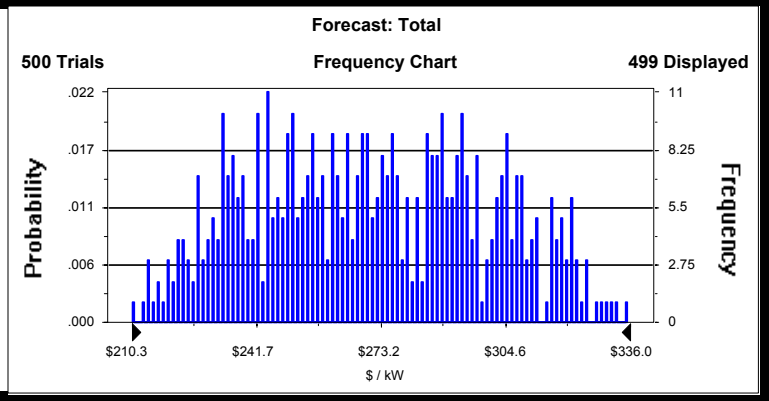
Cost is critical to long-term broad acceptance

Cost Estimation: Monte Carlo Simulation



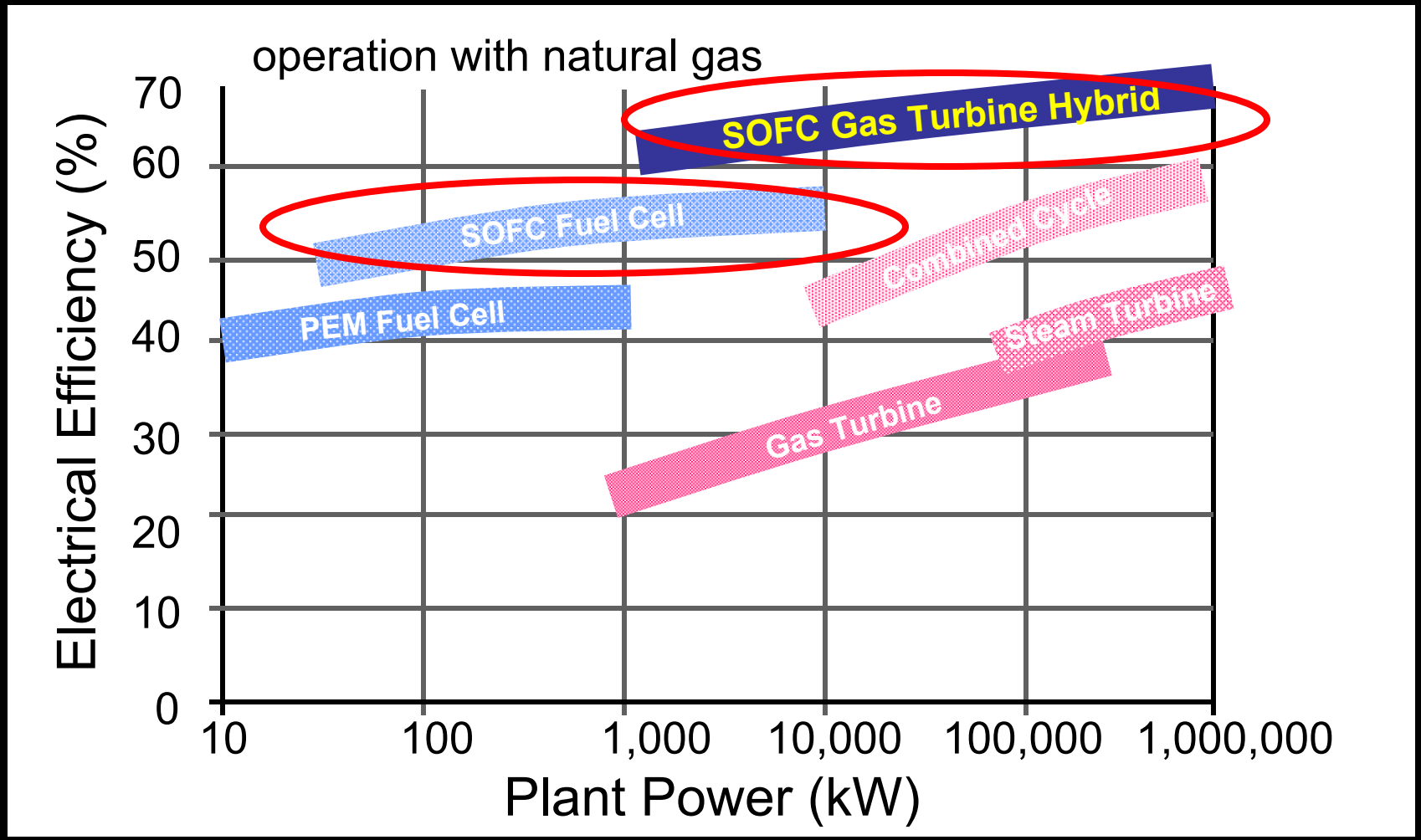






Probabilistic cost analysis provides insight

SOFC & SOFC Hybrids



Benefits in efficiency across broad power range

Summary - SOFC & SOFC Hybrid

- **Potential to be disruptive in power generation industry**
- **Support National Energy Policy goals**
  - **Efficiency & emissions**
  - **Multi-fuel, including coal**
  - **Complementary to hydrogen economy**
- **Significant challenges to realize benefits**
  - **Address via staged development plan**

• Acknowledgements: DOE/NETL and GE SOFC team